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itself, giving 7.662 water-meters, or about 25 feet of water-pressure.

For any other solute than sugar we have only to substitute its molecular weight for the denomination 342 in the above work. Substituting 2 for it, for hydrogen, the result is 1153 water-meters, a forcible token of its lively diffusibility.

The Freezing-Point.—Though this has no connection with physiology, the lowering of the freezing-point in solution is cited by Starling as a step towards finding osmotic-pressure, which we have seen to be determinable in a less troublesome way. We give the converse case; having found the pressure, to ascertain by its aid the freezing point of a 1 p. c. solution of cane-sugar.

The law of thermodynamics gives this proportion:

$$\frac{\text{Work done}}{\text{Heat during it}} = \frac{\text{Lowering } (\triangle) \text{ of Total Heat}}{\text{Total Heat.}}$$

In this case the work done is 6.748 water-meters-pressure (as was found above). The heat doing it is the latent part of water, 79.9 calories per gram, which is reduced to water-meters-pressure by multiplying by 427.

The total heat is the absolute temperature at 0°C.; this is 273. Thus the proportion becomes

$$\frac{6.748}{427\ (79.9)} = \frac{\triangle}{273,}$$

giving $\triangle = 0°.054$ C. This result is substantially identical with that cited by Starling from van't Hoff, and signifies that the particular solution of sugar in water lowers the freezing-point more than one-twentieth of a degree. If the solution had represented a gram-molecule of sugar in a liter of water the depression of the freezing-point would be nearly 2°C., a constant well-known to physicists.

Writers on physiology usually state that processes of absorption within the body are more rapid than can be fully explained by experiments on diffusion. A partial explanation of this peculiarity will, I think, be found in the fact that experiments are made on dead and comparatively rigid membranes, and the living membranes of the body are almost fluid in their softness. Whether osmosis be by a transitory combination or by passing through temporary pores, it involves in the living body a minimum of friction. We know how much more rapidly blood can pass through flexible, living vessels than through rigid tubes.

(I am indebted to my colleague Professor E. H. Loomis for advice.)

GEORGE MACLOSKIE.

PRINCETON UNIVERSITY.

January 5, 1899.

PROFESSIONAL SCHOOLS VS. BUSINESS.

AN exceedingly interesting and instructive experiment has been in progress during the last few years at Sibley College, Cornell University, the outcome of which will perhaps have peculiar interest for all who are concerned with education and professional training, the data of which experiment are exhibited in the accompanying diagram, showing the growth in numbers of that college from its date of reorganization as a professional school, in 1885, to the present time. The diagram is taken from the paper read before the Association of Promotion of Engineering Education, at the Boston meeting of 1898, by the writer.

Up to the year 1885 Sibley College was without expert direction, a definite policy, a settled curriculum or a systematically organized faculty. It had been established as a 'school of the mechanic arts' for many years, but had not graduated a hundred students in its whole career. In 1885 the Trustees of the University found themselves in a position to undertake the work

of reorganization and reconstruction on a higher plane and in a more modern way. Mr. H. Sibley had enlarged and improved the College buildings and greatly added to the outfit of laboratory apparatus and workshops, and it was considered practicable to undertake the inauguration of schools of undergraduate and post-graduate work in the various branches of mechanical engineering and the mechanic arts. Space was available and the apparatus was sufficient to meet the needs, as was thought, of as many as 200 students in its various departments. The institution was placed in the hands of a Faculty composed entirely of professional experts; the course was reconstructed and made mainly technical; the entrance requirements were made to accord, as closely as was thought practicable, with those of the most advanced of existing schools of a similar class, and the equipment was made modern in character and exceptionally extensive in each of its professional branches.

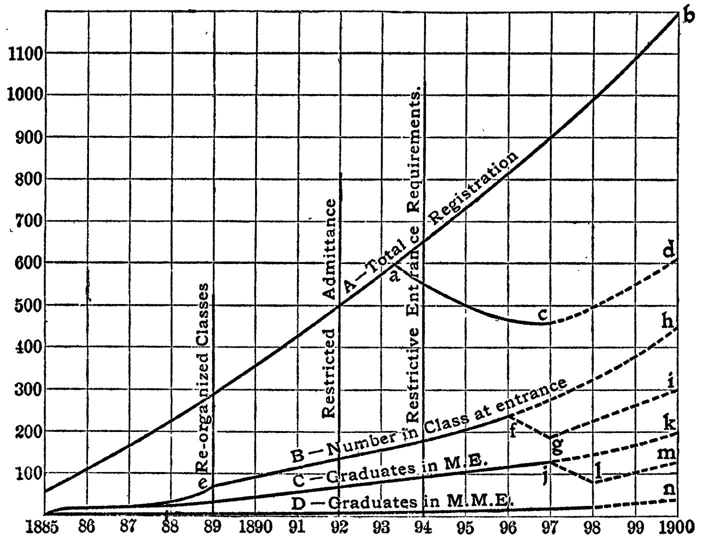
Later, special courses were established, undergraduate and advanced, in electrical engineering, in marine engineering, in railway machine construction, etc., and the College was brought into the form now familiar to our professional educators and technical men.

The immediate result of this reconstruction of the institution was to bring up the attendance from an average, for the earlier years, of about a dozen, with an average of five in the graduating classes, to about a hundred; while the graduating classes in the course of the next four years ran up to 30, in ten years to 100, and while the student-list increased to 400 in five years and to 634 in less than ten. In two years the College had reached its originally estimated limit, and the Director was compelled to notify the Trustees that some means must be found to prevent overcrowding. It was attempted to restrict admissions to the freshman class; but this proved ineffective, as students would then enter other departments of the University, and, later, transfer to the upper classes of Sibley College. Meantime the numbers increased; the faculty was enlarged, new buildings were added and equipment greatly increased, without relief from the continual overcrowding and pressure in all departments and in every phase of work.

Finally it was concluded to adopt a radical and certain method of checking an influx of students which threatened to demoralize the institution by flooding all departments and overworking the whole staff, while, hardly less serious, making heavy inroads upon the always hard-pressed income of the University, which was already overloaded by the enormous demands of the State of New York for State scholarships — now 600 in number — for which no compensation was made to the University. The immediate outcome was the cutting-down of the entering classes 40 per cent., by demanding of them an additional year in mathematics; permitting the freshmen to take up analytical geometry and the calculus, and the sophomores to give their time for the year, in that branch, to applied mechanics, the backbone of every technical course. This was done in 1893, and classes which would have entered about 175 strong were pruned down, by this exclusion of the weakest applicants, to something above 100. The 'cream was skimmed' and a magnificent body of students thus secured; but the result, on the other hand, was then and later the compelling of hundreds of young men to go directly into business, who, otherwise, would have secured a systematic and scientific preparation for their life's work. The facts of this very interesting case are shown in the accompanying diagram, originally from the report of the Director of Sibley College to the Board of Trustees of Cornell University, June,

1898. The experiment, in so definite and conclusive a form, is so unexampled and the results so exceedingly instructive and suggestive to faculties, or others proposing to deal in a radical manner with so delicate a subject, that it has been thought that a wide circulation of these facts would prove acceptable and useful in many ways.

In illustration of the sensitiveness of the average technical college to changes in entrance requirements and consequent changes in its relations to the preparatory schools as now customarily conducted, ignoring demands of any other than aca-



STATISTICS OF SIBLEY COLLEGE, 1885-1900.

demic colleges and universities, it will be instructive to study the accompanying diagrammatic representation of the working of such a change compelled by the increase in numbers of students beyond what was at the time thought a limit for good work and of suitable equipment and accommodations.

The accompanying diagram presents the statistics of growth of Sibley College from 1885, the date of its organization upon its present basis, to 1897–8, and the presumptive changes to A. D. 1900, assuming no further modification of the conditions of entrance and of the course itself, meantime. Referring to the diagram: Following the upper line, *A*, we observe that the total registration began rising instantly upon the establishment of an engineering course, from about 100, in 1886, to 200, nearly, in 1887, 300 in '89, 400 in '90, 500 in '92, and to 638 in the year terminating June, 1894. At this point the non-professional entrance requirements were raised by demanding an additional year of higher mathematics, thus permitting the freshmen to take up analytical geometry and the calculus, and the sophomore class to study and complete applied mechanics—a change which proved of enormous advantage in improvement of the course of study. But the registration necessarily at once dropped off to lower figures, until, in the year 1896–7, the registration of undergraduates was less than 500.

On the other hand, the numbers of the graduating classes continued to rise until this change had its full effect, and numbered 125 in June, '97, but will not exceed, probably, 95 in '99; after which date it may be expected to again resume its upward march. Curves *B* and *C* show the num-

bers of these classes at graduation and at their entrance into the College.

The line *a b* indicates what might have been expected had no such radical and unprecedented increase of the demands at entrance been made. The College would, at its then rate of growth, have attained a census of 1,000 students in 1898 or 1900, possibly 1,200 in the latter year. Numbers were then restricted by thus cutting the expectant entrance-class in half and its numbers fell as shown, and the dotted line, *c d*, indicates where the figures will probably reach, at those dates, as now thus reduced. Similarly, the lines *f h* and *g i* show what numbers were promised, between the specified dates, under the one, and what under the later, arrangement. The lines *j k* and *l m* show what should have been and what actually will probably be the magnitude of the graduating classes, in 1898 to 1900, inclusive. The line *D* indicates the number of students taking the Master's degree. The peculiar 'hump' at the date '89, on *B*, indicates the effect of the unsuccessful attempt to restrict numbers at that date by limiting the number accepted.

Just what is to be considered the real balance between advantage and disadvantage due the noted elevation of the entrance requirements, in '94, is perhaps difficult to decide. It has given a vastly better course; but the difference between the lines *a b* and *c d* shows that the College has lost the opportunity to benefit many hundreds of students who have, as it is, been compelled, in most cases, probably, to go into business without professional training and who are thus placed almost hopelessly in the rear of their more fortunate fellows in their struggle for success through life.*

R. H. THURSTON.

SIBLEY COLLEGE, CORNELL
UNIVERSITY, January 2, 1898.

* Proceedings Society for Promotion of Engineering Education, 1898.

MECHANICAL ILLUSTRATION OF KIRCHOFF'S PRINCIPLE.

IN teaching the reversal of the metallic lines in the Fraunhofer spectrum it is often difficult for the student to get a concrete idea of the principle that a molecule or atom will absorb especially radiant energy whose period is identical with the inherent period of the molecule itself.

A customary method of illustrating this point is with two tuning forks upon resonance boxes, but this requires very careful manipulation and is not altogether satisfactory. The following method has proved quite satisfactory:

The suggestion of Lord Kelvin for a mechanical illustration of a molecule having inherent periods of vibration is used, replacing his spherical shells by rings. Such a molecule with one rate is shown in Fig. I.

The ring *A* is about 20 cm. in diameter and made of brass rod about 1 cm. in diameter; the ball *B* is preferably somewhere near the same mass as the ring *A*. The three spiral springs *S* are wound about 2 cm. diameter of about No. 22 hard brass wire.

Such a molecule has a rate of vibration of about 4 or 5 per second when suspended on a long string as at *D*. A close spiral spring *C*, similar to *S*, but about 50 cm. long, is attached to the ring at *E*, the other end being held between the thumb and finger at *TF*.

While holding this spring slightly tense it can be set into longitudinal stationary waves by compressing the part at *P* toward *TF* and then letting go. The period of these vibrations depends upon the length *TF* to *E*. Commencing with this length about 15 to 20 cm., it will be observed that the stationary waves in *C* do not effect the molecule. Taking *C* longer and longer a point is reached where the waves in *C* are taken up and a decided vibration is set up between *A* and *B*. That is, the molecule absorbs the energy from *C* when its period